Recent IR Metrology Work on MPI

21 January, 1997

OUTLINE

1. Objectives
2. Tools
3. Measurements
4. Results
5. Futurework

Objectives of MPI Metrology Work

* Overhaul MPI infra−red metrology system
* Understanding the laboratory environment and its effect on MPI
* Bridge the gap between the MAM "disturbance free" metrology environment and the MPI "disturbance rich" metrology environment

Seminar Objectives

* Report on recent IR−metrology related work at MPI
* Receive feedback, to be used for planning subsequent work

Tools

* Sensors

  −IR metrology sensors − oldstyle, refurbished

  −IR beam pointing sensor

  −Temperature probes, ~ 2 mK resolution

Calibration of metrology and pointing sensors: micrometer driven stage to impart known displacement to sensor

* Disturbances

  1. Controlled:

     − Simulated HST reaction wheel disturbance, at 2618 rpm

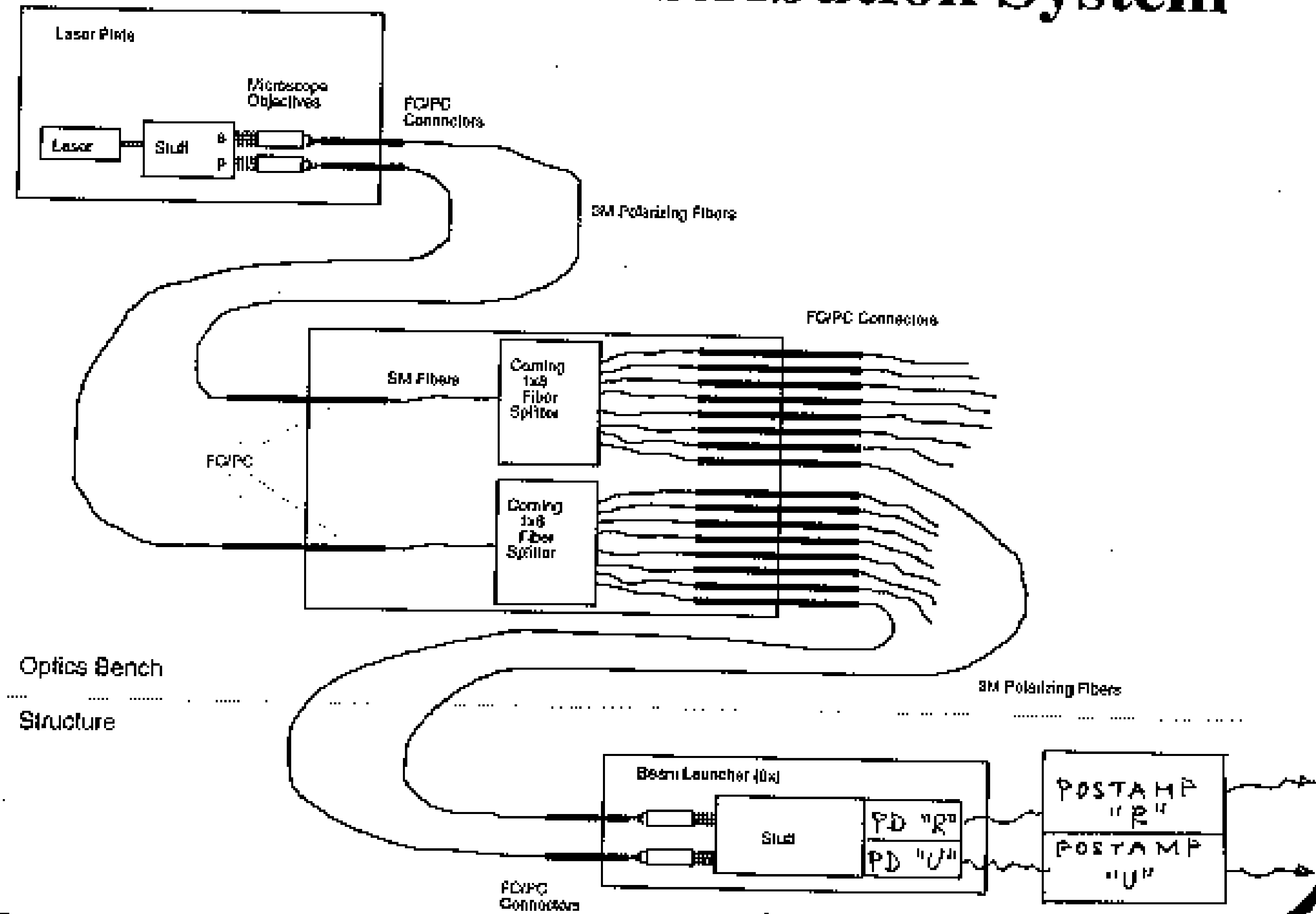
     −Siderostat−induced disturbance:

       − open−loop slew

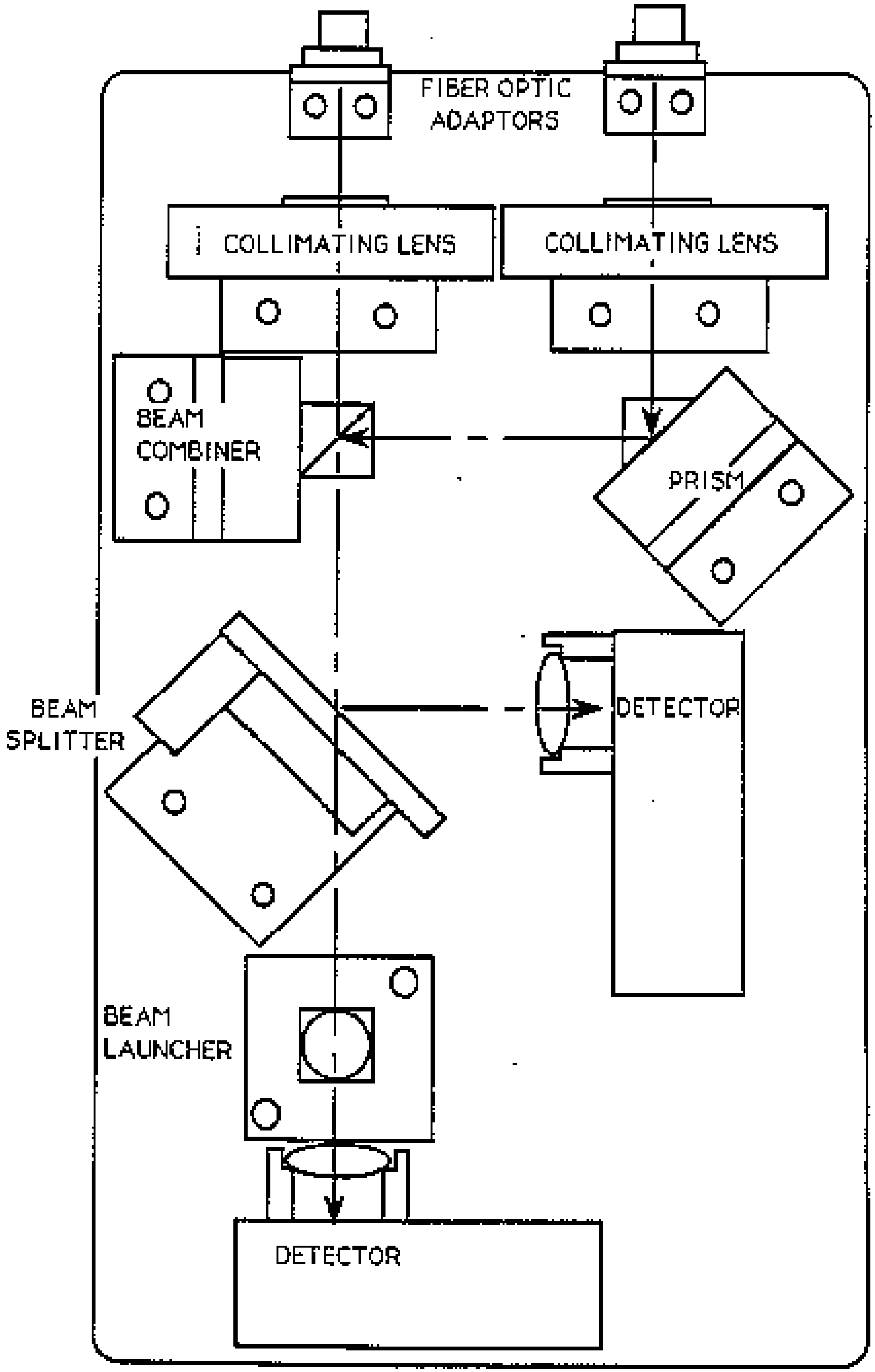
       − closed loop operation

  2. Uncontrolled: Laboratory thermal and vibration environment

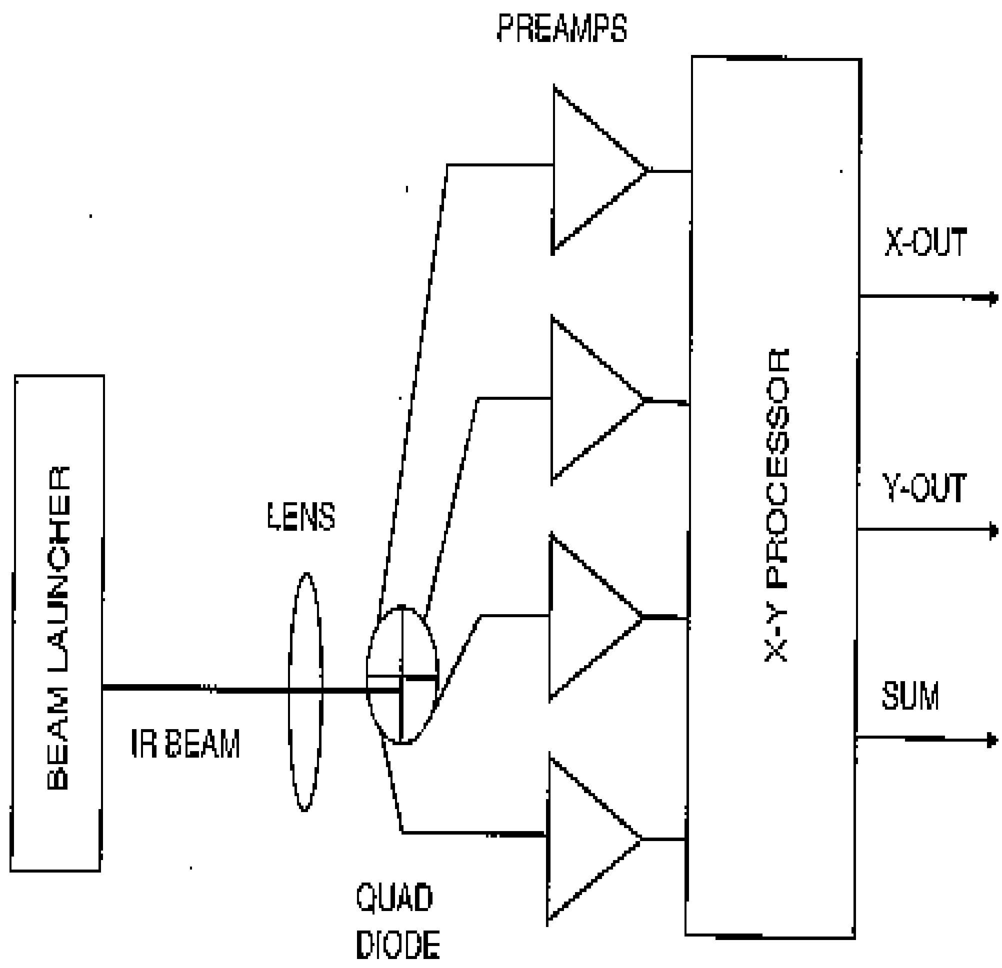
Fiber Distribution System



BEAM LAUNCHER ASSEMBLY



IR Beam Pointing Sensor

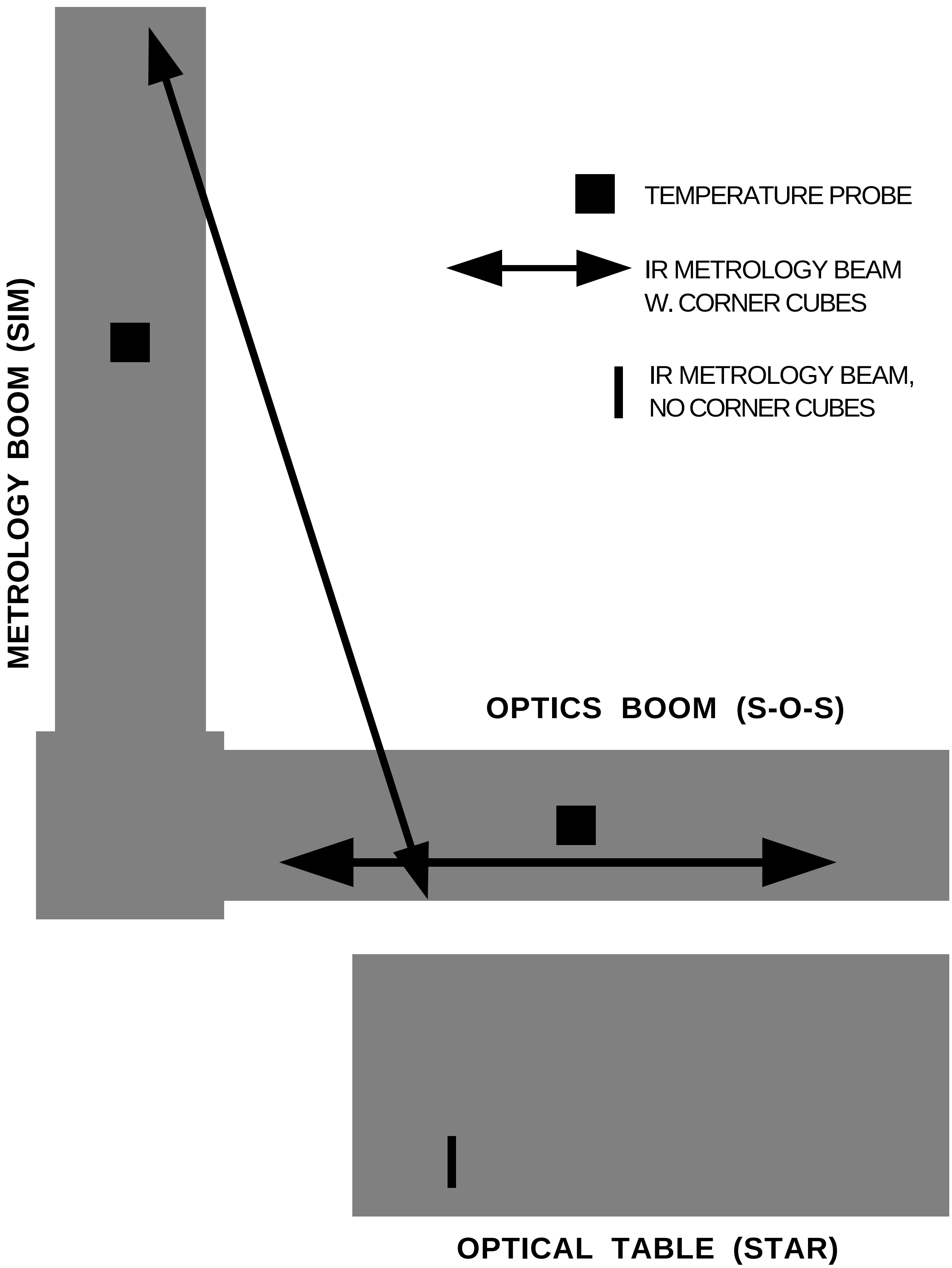


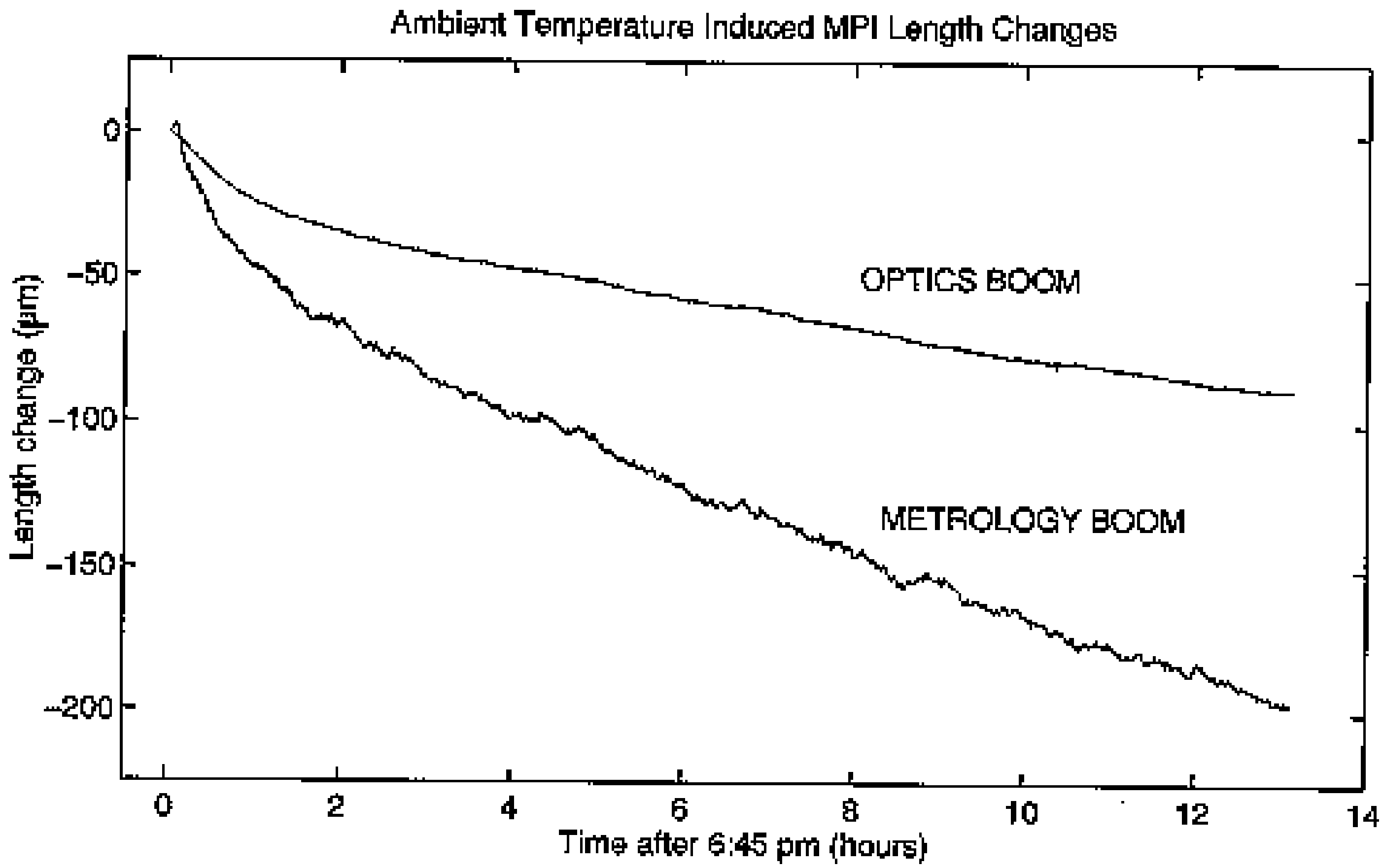
MEASUREMENTS

1. Long term (days), for insight into MPI operation

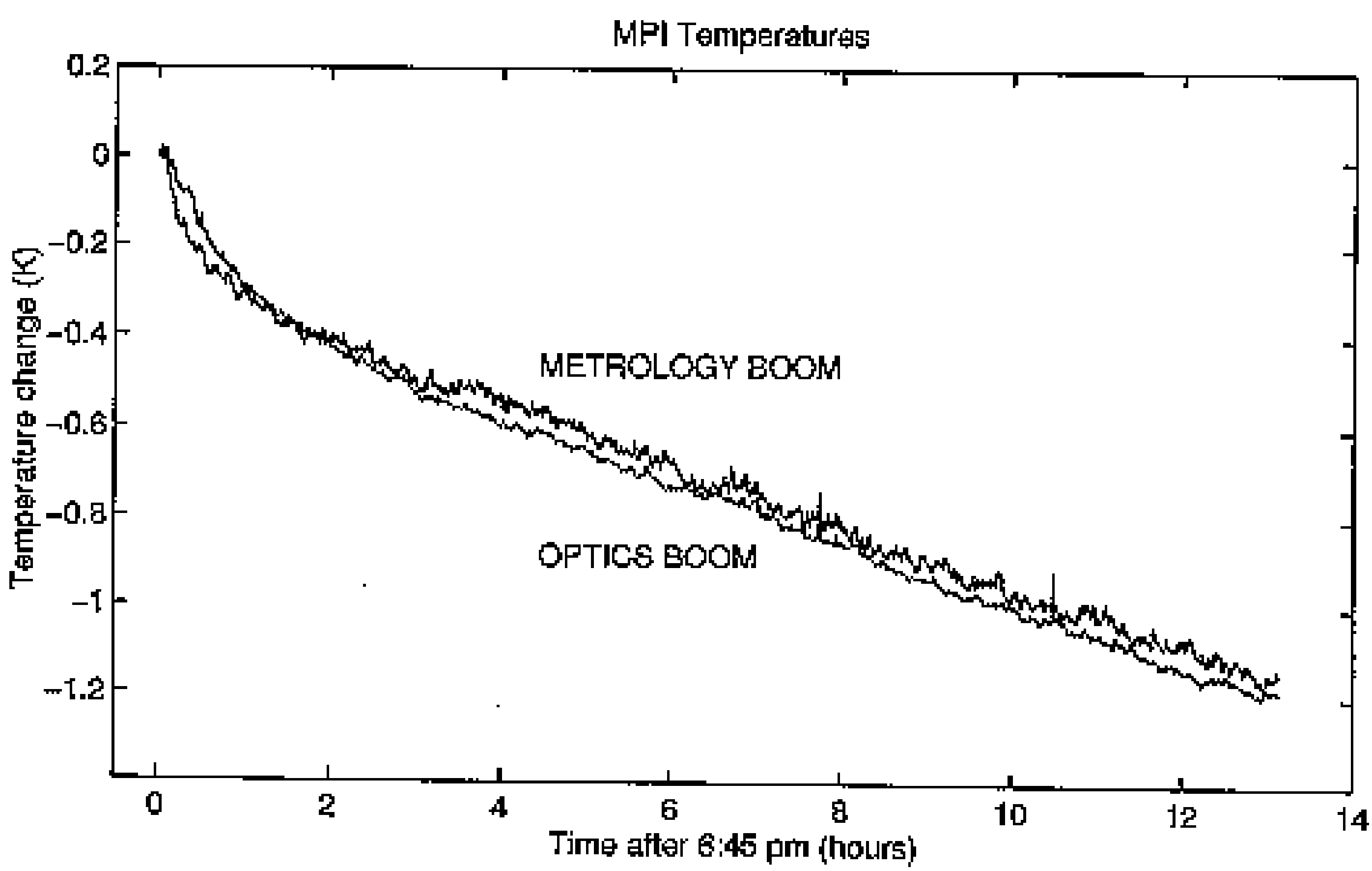
2. Short term (seconds), for insight into MAM/MPI metrology "bridge"

ARRANGEMENT FOR LONG-TERM MEASUREMENTS





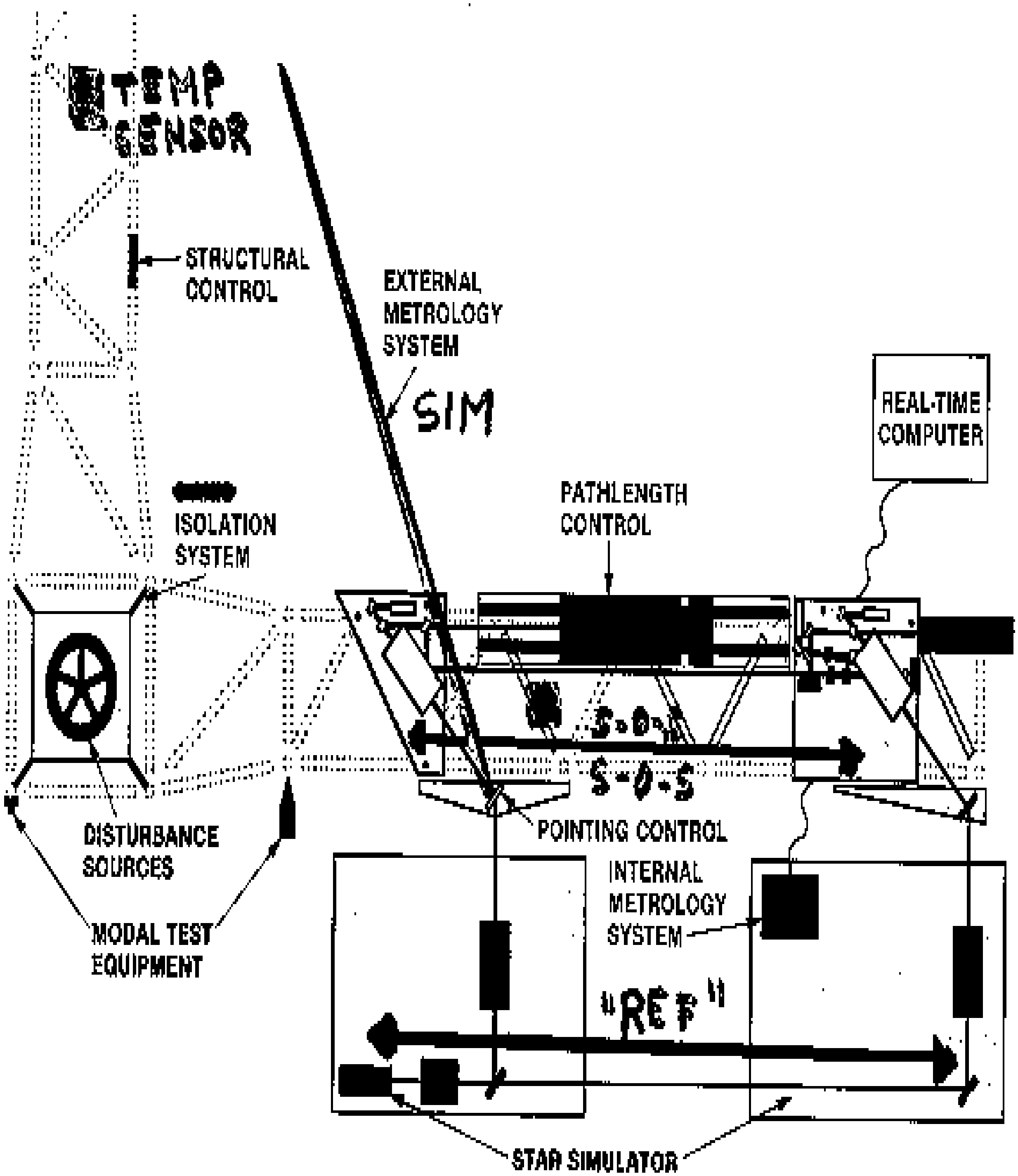
Ambient Temperature Induced MPI Length Changes
Length change (µm)
0
-50
-100
-150
-200
OPTICS BOOM
METROLOGY BOOM
0
2
4
6
8
10
12
14
Time after 6:45 pm (hours)

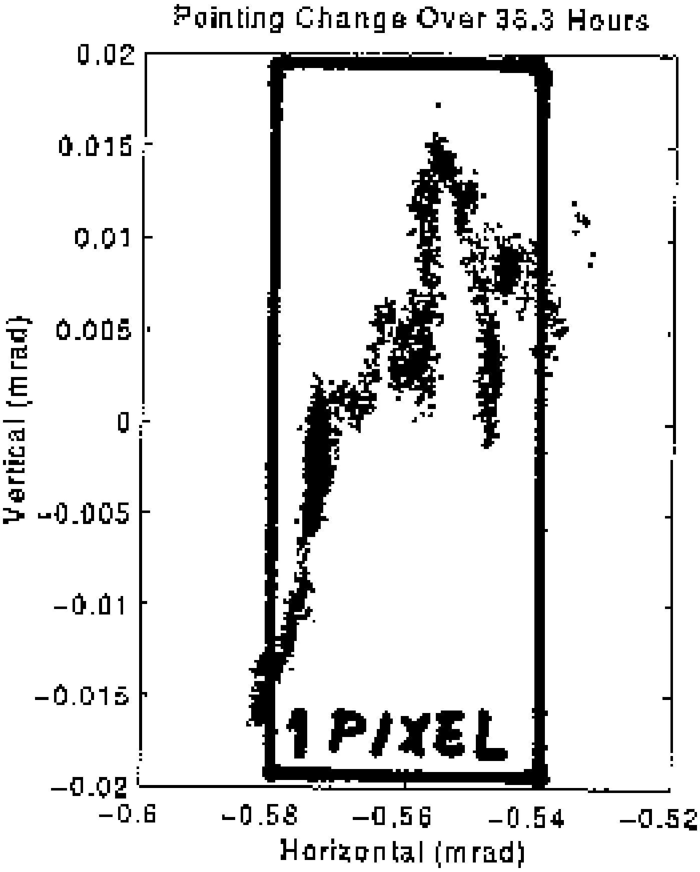


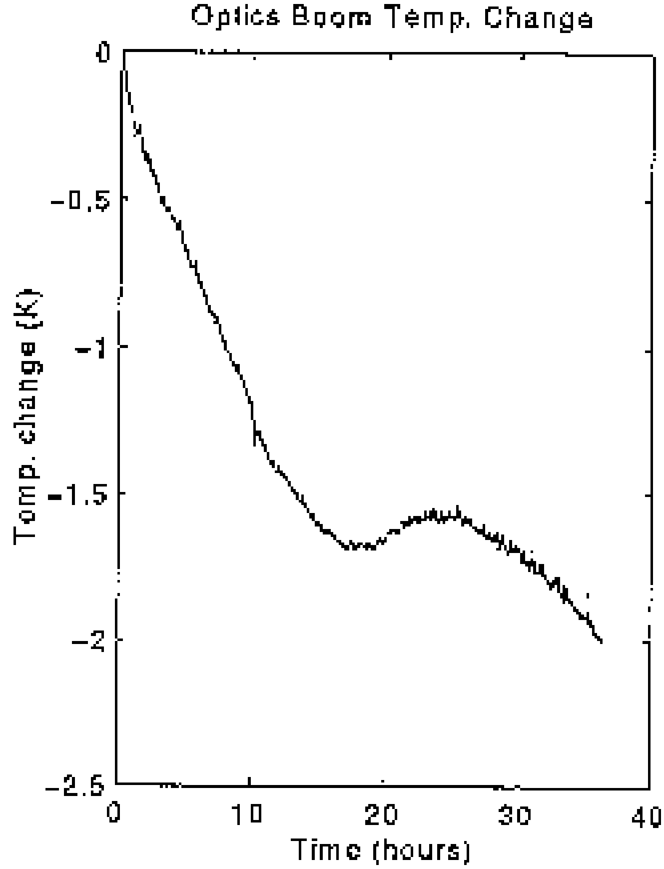
MPI Temperatures
Temperature change (K)
0.2
0
-0.2
-0.4
-0.6
-0.8
-1
-1.2
METROLOGY BOOM
OPTICS BOOM
0
2
4
6
8
10
12
14
Time after 6:45 pm (hours)

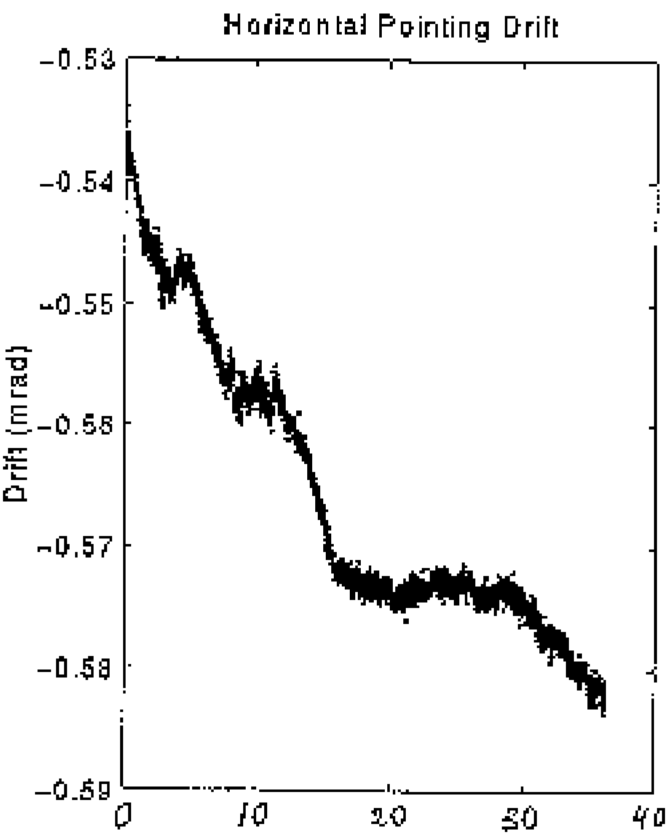
JPL

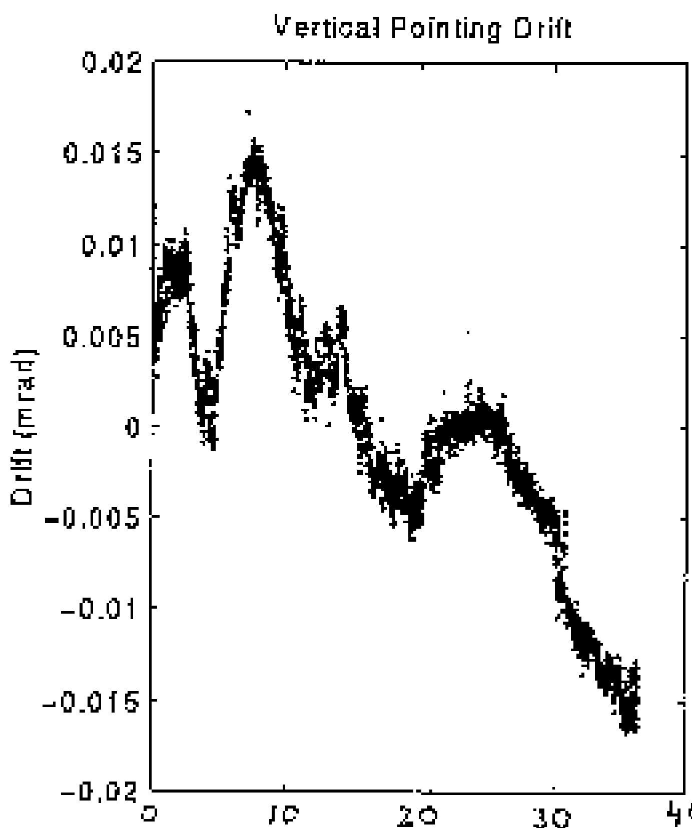
MICRO-PRECISION INTERFEROMETER TESTBED: INTEGRATION AND TESTING OF CSI TECHNOLOGIES



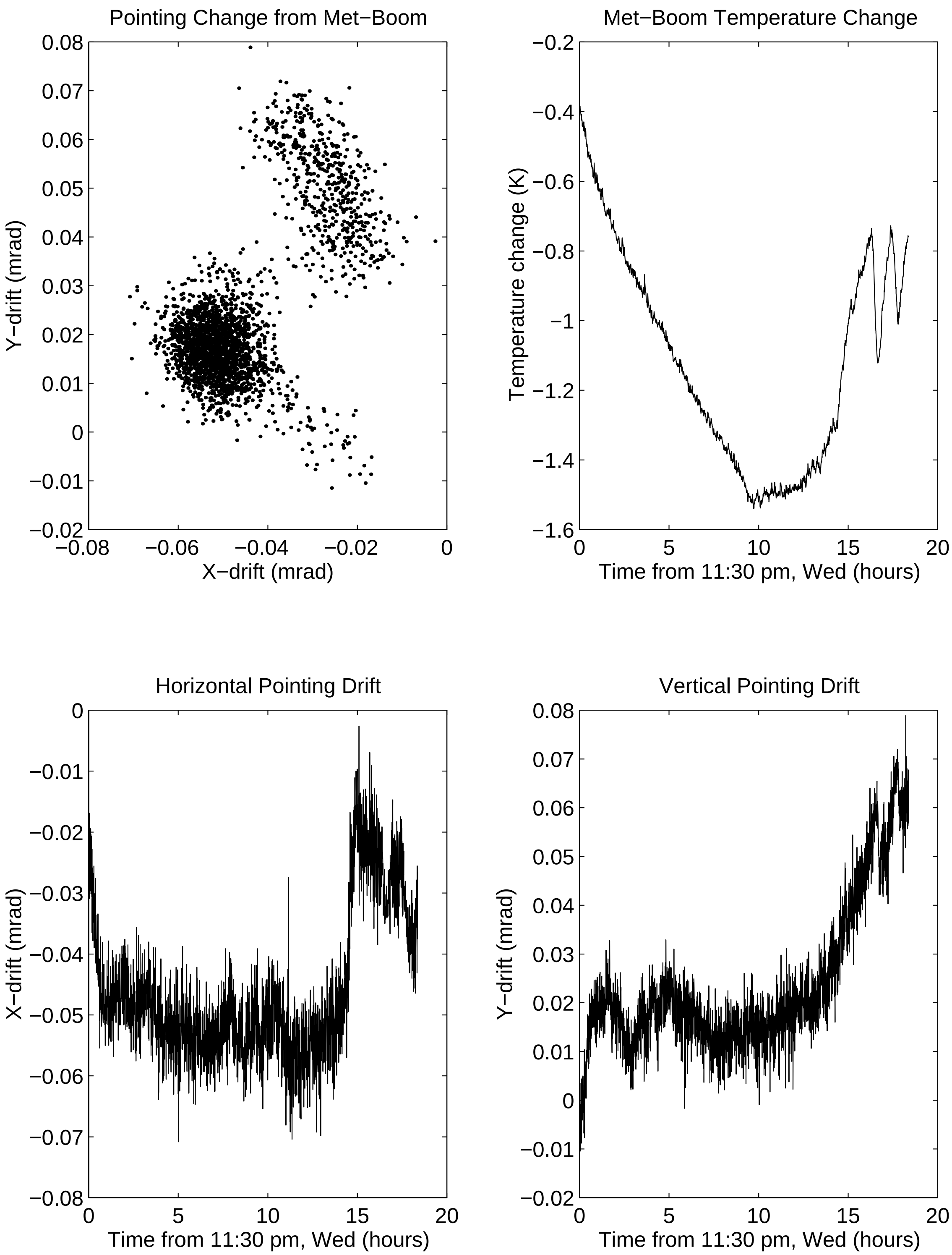




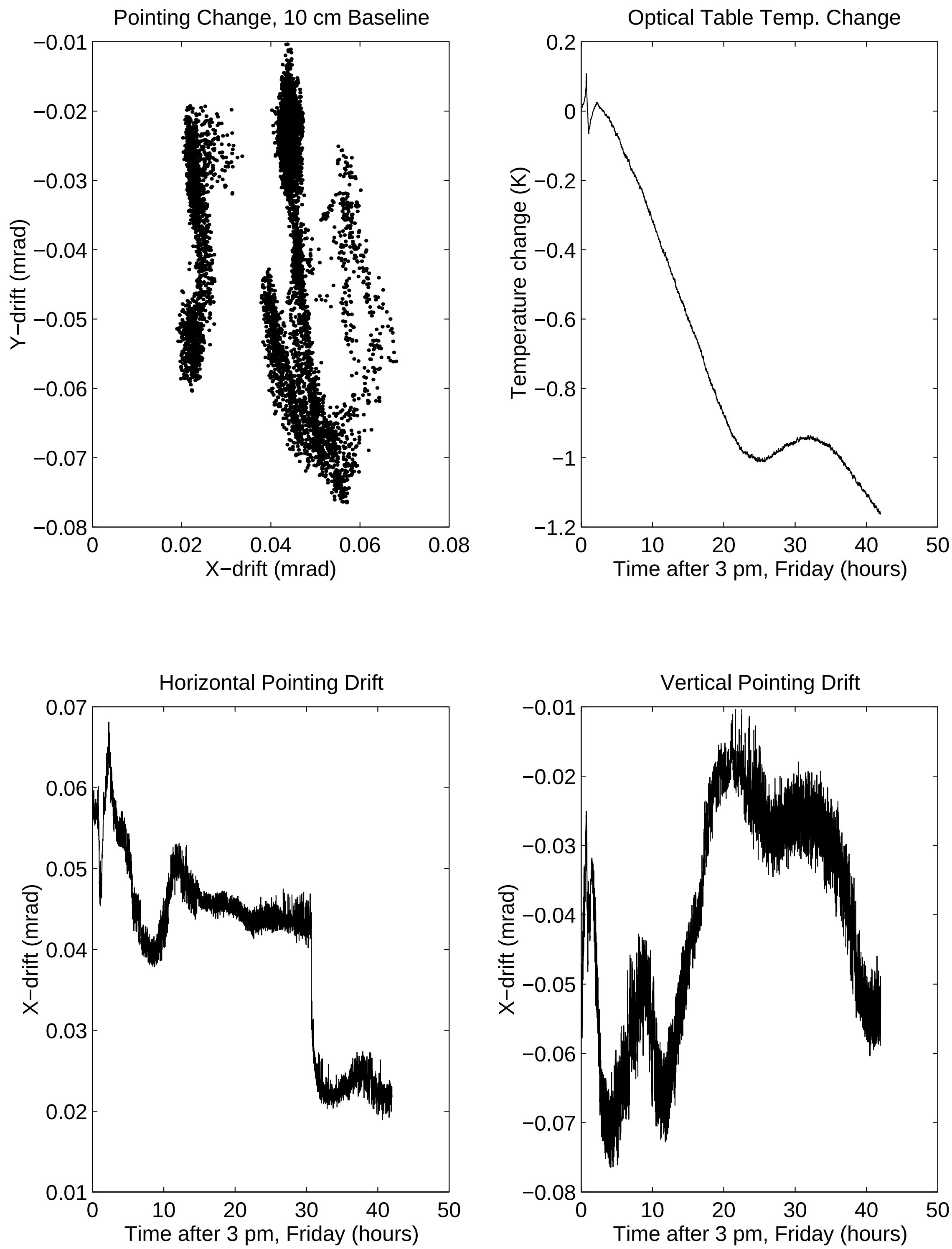




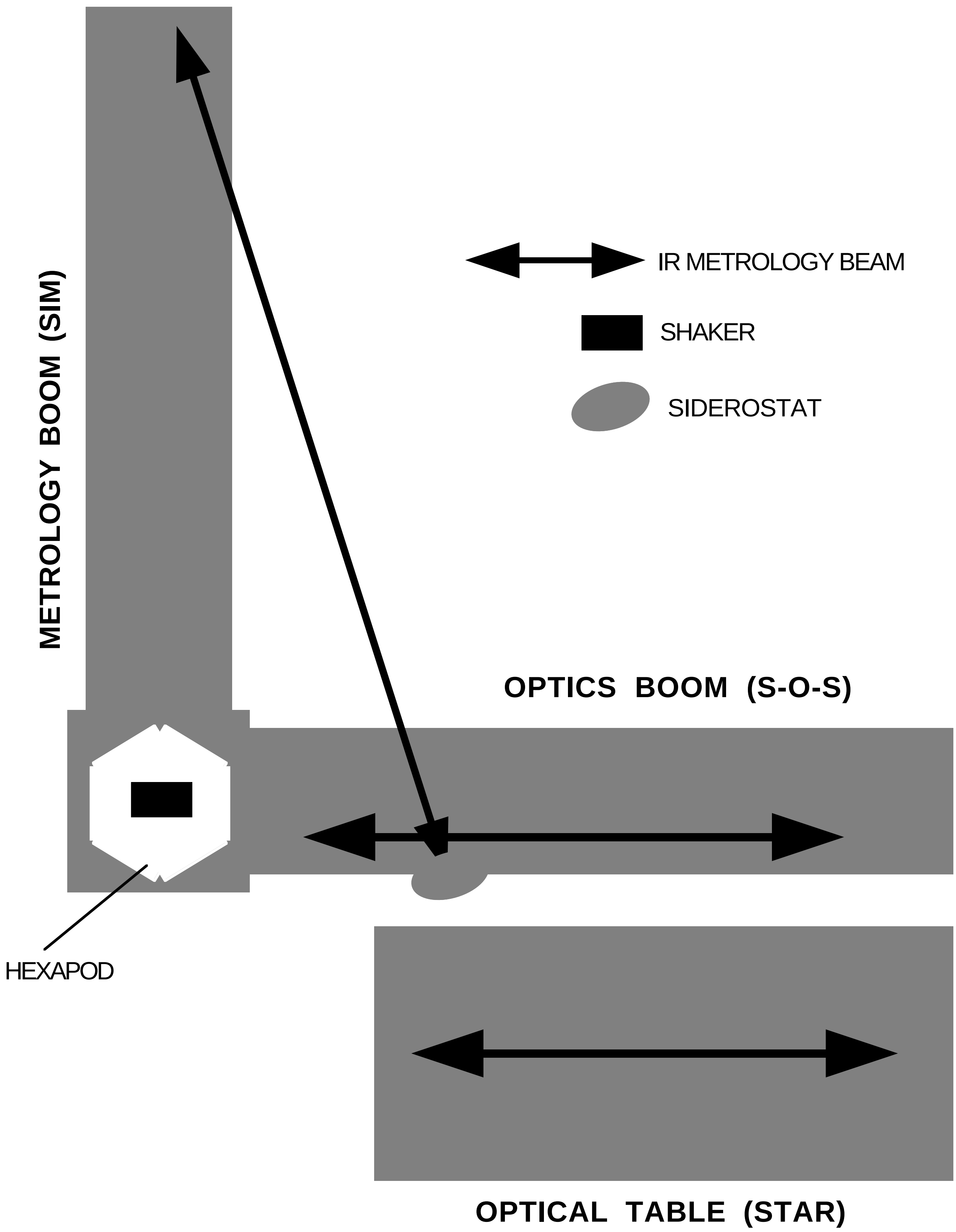
TIME (0 to 40 hours)

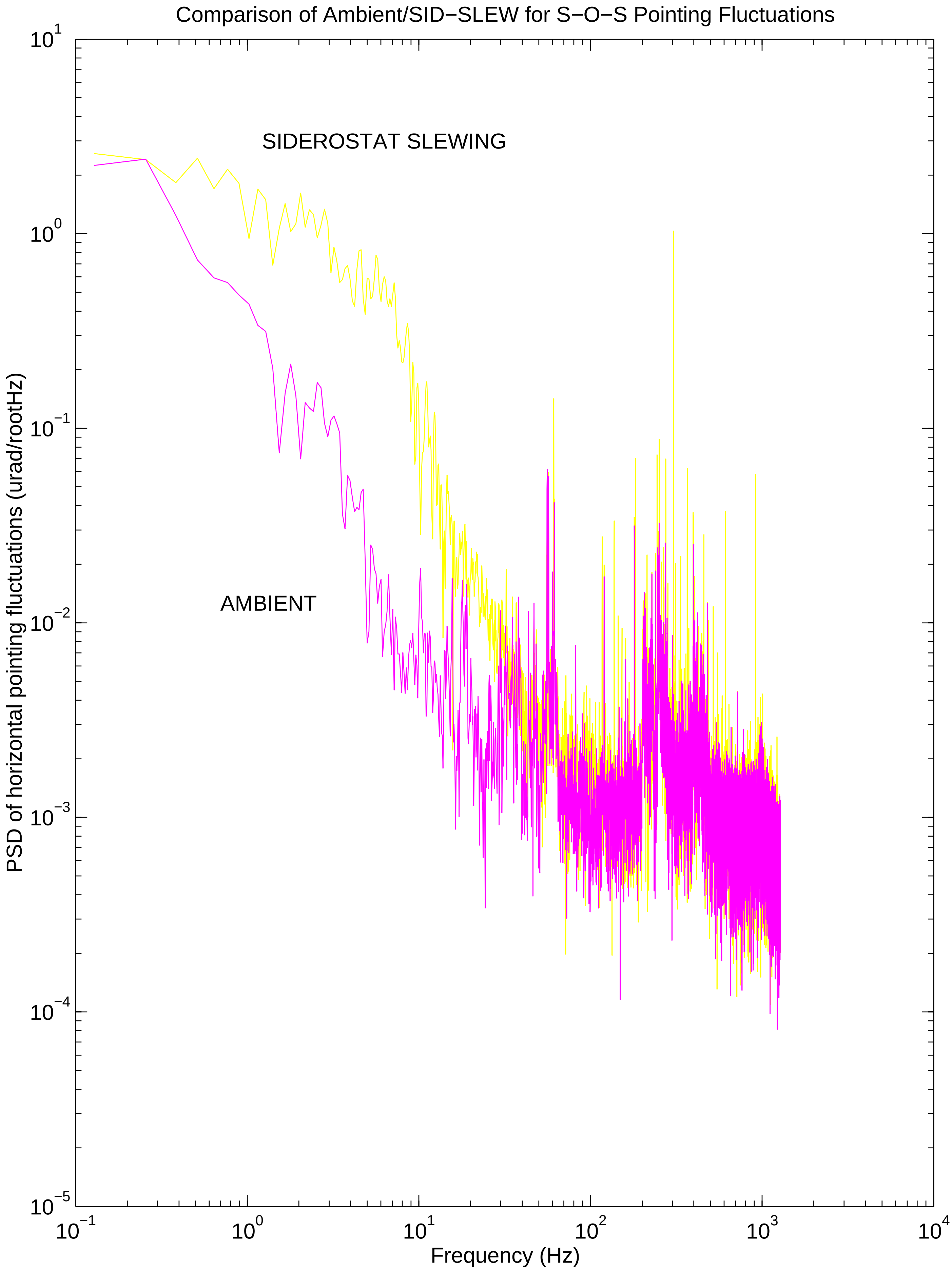


Pointing Change from Met−Boom
Y−drift (mrad)
X−drift (mrad)
Met−Boom Temperature Change
Temperature change (K)
Time from 11:30 pm, Wed (hours)
Horizontal Pointing Drift
X−drift (mrad)
Time from 11:30 pm, Wed (hours)
Vertical Pointing Drift
Y−drift (mrad)
Time from 11:30 pm, Wed (hours)

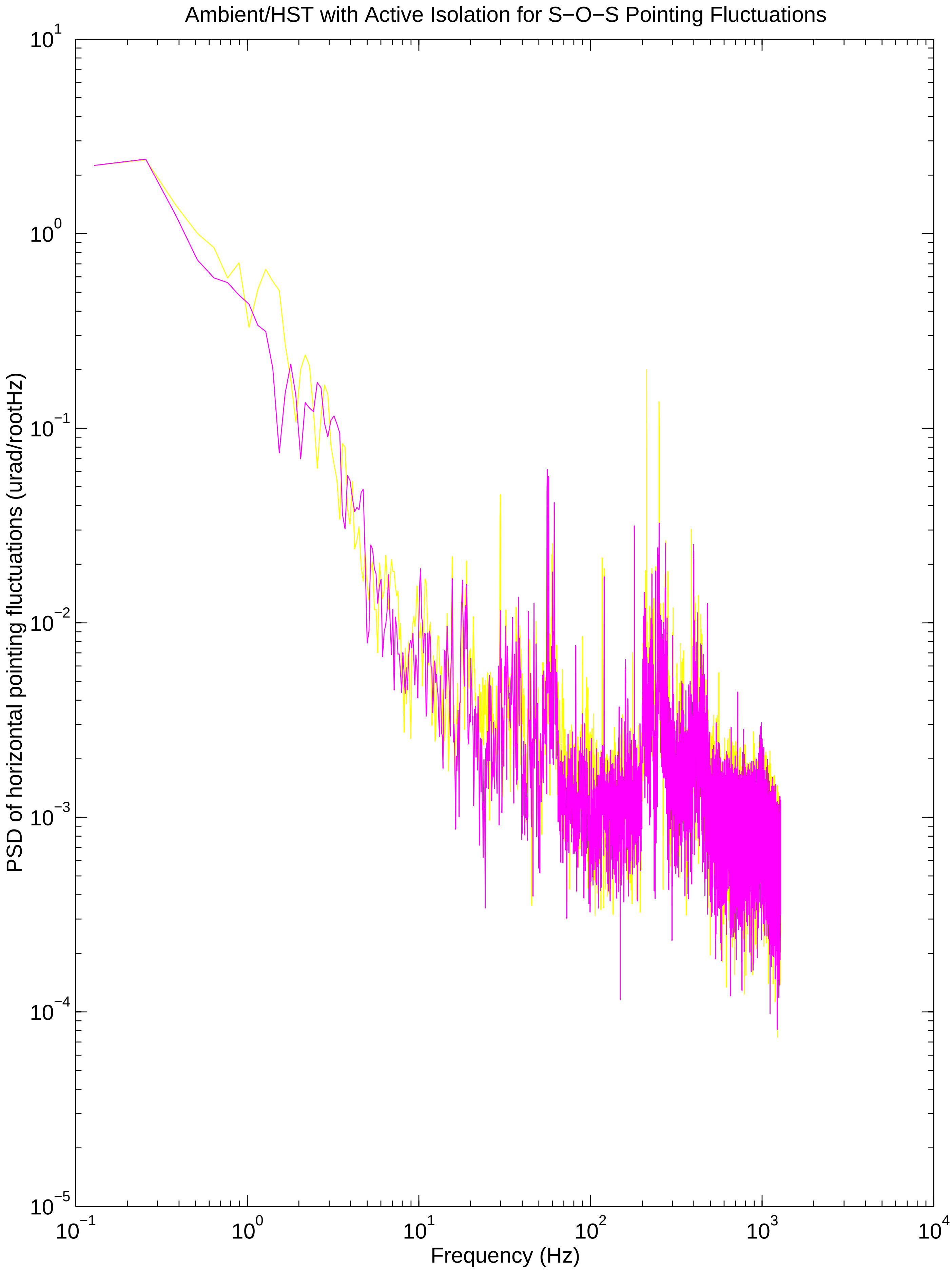

Pointing Change, 10 cm Baseline
Y−drift (mrad)
X−drift (mrad)
Optical Table Temp. Change
Temperature change (K)
Time after 3 pm, Friday (hours)
Horizontal Pointing Drift
X−drift (mrad)
Time after 3 pm, Friday (hours)
Vertical Pointing Drift
X−drift (mrad)
Time after 3 pm, Friday (hours)

ARRANGEMENT FOR SHORT-TERM MEASUREMENTS



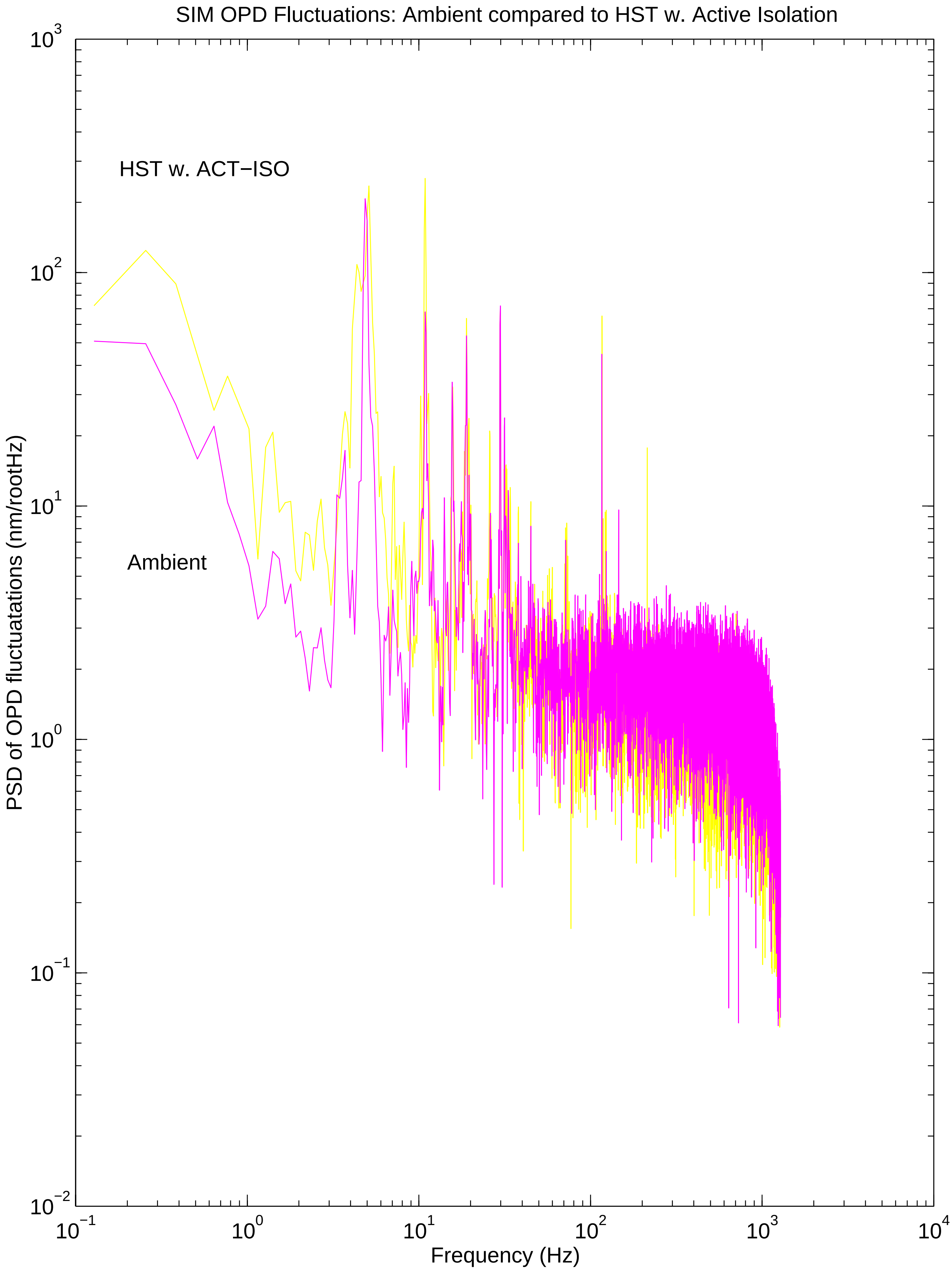


Comparison of Ambient/SID−SLEW for S−O−S Pointing Fluctuations
SIDEROSTAT SLEWING
AMBIENT
PSD of horizontal pointing fluctuations (urad/rootHz)
Frequency (Hz)
10^{1}
10^{0}
10^{-1}
10^{-2}
10^{-3}
10^{-4}
10^{-5}
10^{-1}
10^{0}
10^{1}
10^{2}
10^{3}
10^{4}


Ambient/HST with Active Isolation for S−O−S Pointing Fluctuations
PSD of horizontal pointing fluctuations (urad/rootHz)
Frequency (Hz)
10^{1}
10^{0}
10^{-1}
10^{-2}
10^{-3}
10^{-4}
10^{-5}
10^{-1}
10^{0}
10^{1}
10^{2}
10^{3}
10^{4}

Disturbance Source	RMS Pointing Fluctuations of IR Beams (μrad)				
	0.1-1 Hz	1-10 Hz	10-100 Hz	100-1000 Hz	All Freqs.
SON-OF-SIM					
Ambient	1.49~6.9pm	0.427~2pm	0.067~0.3pm	0.11~0.5pm	1.55~7.1pm
HST y-react. wheel, pas. isol.	**3.1**	1.74	0.13	0.21	**3.56**
HST y-react. wheel, act. isol.	**1.57**	0.56	0.1	0.22	1.68
SID w. active control	**1.11**	0.46	0.13	0.44	1.3
SID slewing 15°/5 min.	**2.56**	**2.67**	**0.25**	**0.82**	**3.8**
SIM					
Ambient	**3.45**	**2.7**	**1.24**	**0.38**	**4.57**
Another ambient	4.59	2.8	0.36	0.32	5.4
HST y-react. wheel, pas. isol.	4.04	3.52	**1.24**	0.37	5.5
HST y-react. wheel, act. isol.	4.36	4.96	**1.53**	0.38	6.78
HST x-react. wheel, act. isol.	4.77	5.67	1.66	0.49	7.6
SID w. active control	4.13	3.89	1.15	0.85	5.85
SID w. holding torque	3.24	2.86	0.99	0.43	4.46
SID slewing 15°/5 min.	5.93	3.85	1.13	0.74	7.2

Note: SIM and S-O-S data taken one day apart



SIM OPD Fluctuations: Ambient compared to HST w. Active Isolation
HST w. ACT−ISO
Ambient
PSD of OPD fluctuatations (nm/rootHz)
Frequency (Hz)
10^3
10^2
10^1
10^0
10^−1
10^−2
10^−1
10^0
10^1
10^2
10^3
10^4

Disturbance Source	RMS OPD Fluctuations of IR Beams (nm)				
	0.1-1 Hz	1-10 Hz	10-100 Hz	100-1000 Hz	All Freqs.
SON-OF-SIM					
Ambient1	72.5	31.6	79.4	88.8	143
Ambient2	10.6	16.3	67.7	78.6	105.6
Ambient3	5.95	10	45.4	52.1	70
Ambient4	9.26	10.1	51.9	52.2	74.9
HST y-react. wheel, passive isol.	62.3	19.4	53.2	51.7	98.8
HST y-react. wheel, active isol.	22.5	20.4	52	53.5	80.6
SID w. active control	41.5	39	63.4	88.5	122.8
SID w. holding torque	20.1	23.9	58.2	66.5	93.7
SID slewing 15°/5 min.	26.7	19	51.2	66.3	89.9
SIM					
Ambient1	31.4	144.3	87.1	78.1	188.4
Ambient2	44.3	121.4	70.2	74.3	164.7
Ambient3	29.9	103.2	65.7	58.1	138.7
Ambient4	22.4	37.5	58	57	92.3
HST y-react. wheel, passive isol.	75.7	129.2	616	60.6	636.8
HST y-react. wheel, active isol.	65.8	146.4	129.1	51.1	212.2
SID w. active control	50	67.3	84.2	87.5	147.5
SID w. holding torque	53.6	102.6	75.4	75	157.2
SID slewing 15°/5 min.	54.1	99.4	77	82.5	159.7
Note: SIM and S-O-S data taken simultaneously					
SON-OF-SIM/STAR Optical Table Comparison					
S-O-S, ambient	21	7.9	31.6	24.7	46
STAR, ambient	94.4	42	5.9	15.6	104.6
Note: STAR and S-O-S data taken simultaneously					

Conclusions

1. Observed long term pointing fluctuations could explain coarse acquisition noise
2. Observed longterm OPD changes are consistent with pure thermal expansion
3. Beam launcher design must address thermal stability
4. Siderostat slewing disturbance causes largest IR beam pointing fluctuations.
5. Measured ambient−induced beam pointing fluctuations correspond to a 7.1 pm OPD error for S−O−S and 24.8 pm for SIM
6. Estimated spacecraft−induced disturbances are at or below the MPI ambient levels

Future Work?

1. Understand and attempt to control the ambient disturbances
2. Devise ways to measure below ambient disturbances
3. Add metrology triangle to MPI and triangulate on a siderostat
4. New IMOS validation measurements
5. Your suggestions